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**United States Patent** [19]

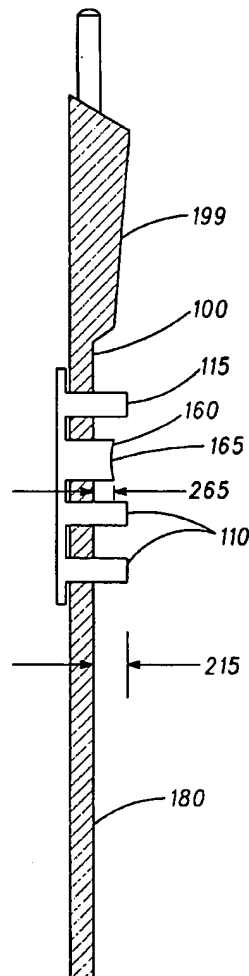
Lindeman et al.

[11] **Patent Number:** **5,926,119**[45] **Date of Patent:** **Jul. 20, 1999**[54] **NUMERIC KEYPAD CONFIGURATION**[75] **Inventors:** Phillip E. Lindeman, Gurnee; Rudy Krolopp, Lake Zurich, both of Ill.[73] **Assignee:** Motorola, Inc., Schaumburg, Ill.[21] **Appl. No.:** 08/771,721[22] **Filed:** Dec. 20, 1996[51] **Int. Cl.<sup>6</sup>** ..... H03K 17/94[52] **U.S. Cl.** ..... 341/22; 379/368; 364/709.12[58] **Field of Search** ..... 341/20, 22; 200/5 A;  
235/145 R; 400/486, 488, 489; 364/709.12;  
345/157; 379/368[56] **References Cited****U.S. PATENT DOCUMENTS**

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*Primary Examiner*—Michael Horabik*Assistant Examiner*—Albert K. Wong*Attorney, Agent, or Firm*—Sylvia Chen[57] **ABSTRACT**

A numeric keypad configuration facilitates accurate key-presses by varying key heights to provide obvious tactile feedback to a user. A home key (160) in a keypad (100) has a lower height (265) than the other keys in the matrix. After locating the home key using touch, surrounding keys can be quickly and accurately located also without looking at the keypad. Additionally, instead of printing a number or letter on the surface of a small key, alphanumeric labels (120) are provided in the spacing area between the keys on the telephone front housing (180) and illuminated, thus improving visibility of the numbers and letters in dim lighting situations. This numeric keypad configuration can be used on cellular telephone keypads or any electronic device where a small numeric keypad is desirable.

**15 Claims, 1 Drawing Sheet**

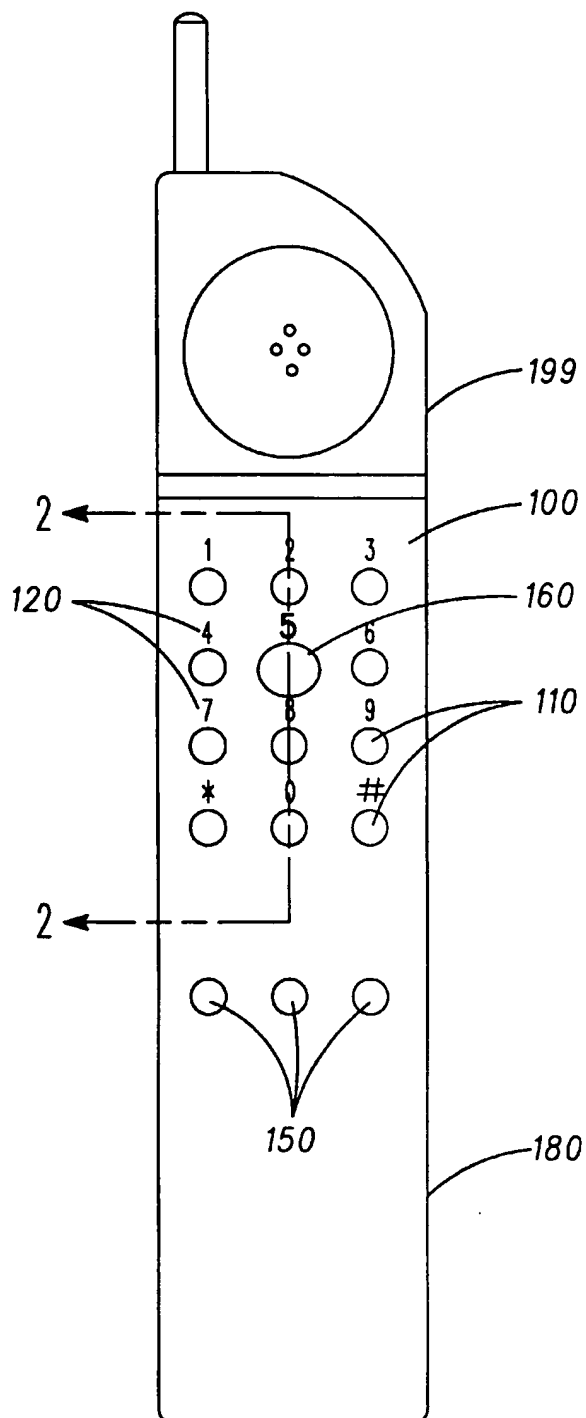


FIG. 1

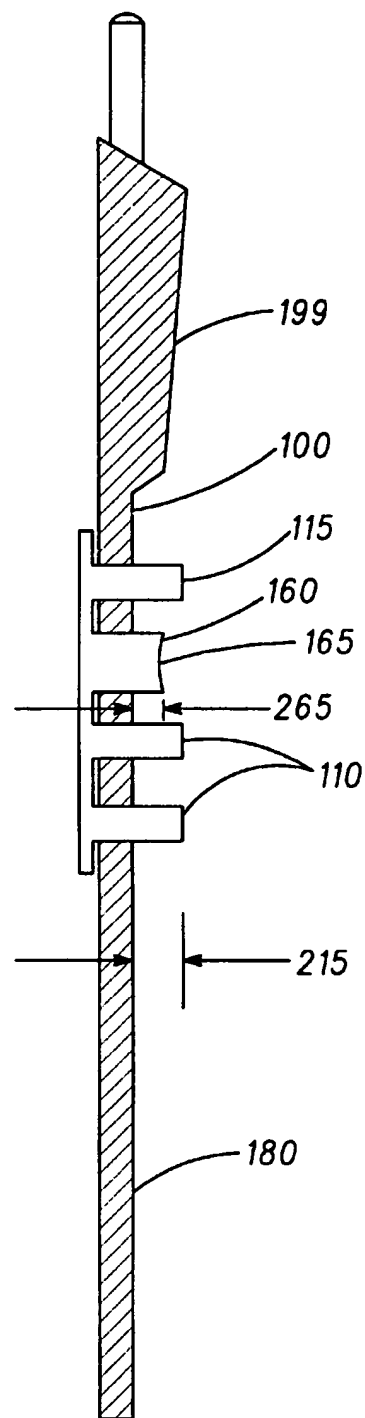


FIG. 2

## NUMERIC KEYPAD CONFIGURATION

### CROSS REFERENCE TO RELATED APPLICATIONS

This application is related to U.S. patent application Ser. No. 08/625,382, filed Apr. 1, 1996 by inventors Krolopp et al. The related application is assigned to the assignee of the present application, and it is hereby incorporated herein in its entirety by this reference thereto.

### FIELD OF THE INVENTION

This invention relates generally to electronic devices, and more particularly to a numeric keypad configuration for a portable electronic device.

### BACKGROUND OF THE INVENTION

Various numeric keypads, such as those found on cash registers and extended computer keyboards, often have keys with bumps or other protrusions on their top surfaces to indicate the presence of a home key. These slight protrusions are helpful for touch typists, who are able to type without looking at the keyboard, because the bumps provide subtle tactile feedback to the typists to indicate that their hands are positioned properly on the keyboard.

For smaller and lighter portable electronic devices, numeric keypads are shrinking and consequently have smaller and smaller numbers and letters printed on top. Sometimes, a user cannot easily read the letters and numbers on a numeric keypad, especially in dim light or when they are involved in an activity such as driving. Because of this, users of these electronic devices sometimes experience difficulty in correctly pressing the keys of the numeric keypad. This drawback exists for users of cellular telephones and other portable electronic devices with numeric keypads. Thus, there exists a need for a numerical keypad configuration that promotes quick and accurate depression of a proper key even when the user cannot see the keys or is not looking at the keys.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a front view of a numeric keypad according to a preferred embodiment.

FIG. 2 shows a cross-sectional view of the keypad taken along line 2—2 in FIG. 1.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A numeric keypad configuration facilitates accurate keypresses by varying key heights to provide obvious tactile feedback to a user. A central or home key in a matrix of keys has a lower height than the other keys in the matrix. After locating the home key using touch, surrounding keys can be quickly and accurately located also without looking at the keypad. Additionally, instead of printing a number or letter on the surface of a small key, an alphanumeric label is provided in the spacing area between the keys on the telephone housing and illuminated, thus improving visibility of the numbers and letters in dim lighting situations. This numeric keypad configuration can be used on cellular telephone keypads or any electronic device where a small numeric keypad is desirable.

FIG. 1 shows a front view of a numeric keypad of an electronic device according to a preferred embodiment. The electronic device 199 pictured is a portable radiotelephone,

however, other electronic devices with numeric keypads, such as computers, electronic typewriters, electronic cash registers, and facsimile machines, can include the numeric keypad. This keypad 100 is designed primarily for one-handed operation where a single finger is used to press all the keys in a sequence. In the portable radiotelephone implementation shown, the keypad is easiest to operate when four fingers and the palm of one hand are cradling the portable radiotelephone and the thumb is used to dial a telephone number.

Keypad 100 includes one or more keys 110 arranged in a matrix and one or more alphanumeric labels 120 in a front housing 180 preferably constructed of molded plastic. A central or home key 160, such as a "5" key, has a recessed height compared to the height of the other keys. Or, in other words, the non-home keys have an enhanced key height compared to the home key. The height difference between the home key 160 and the non-home keys should be obvious to users, so that even when they do not look at the keypad, users can locate the home key using a large and relatively insensitive finger such as a thumb. A height difference as small as one millimeter can be felt by a user. If that one millimeter height difference represents over ten percent of the non-home key height, the height difference between the non-home key and the home key should be obvious to users.

In order to further facilitate location using only the sense of touch, the home key 160 preferably has a slightly different shape compared to the other keys. For example, the home key 160 shown has a slightly larger surface than the other keys. Also, the home key 160 preferably has a surface that contrasts with the surface of the other keys. A concave home key surface that is differentiated from flat or convex non-home key surfaces encourages a finger to brush across the keypad surface to locate other keys yet return confidently to the home key. This obvious tactile feedback is especially useful in dialing situations when users cannot see the keypad clearly, such as while driving, in dim light situations at restaurants, and when users are vision impaired.

Alphanumeric labels 120 are provided directly on the front housing 180 in the area above each key and preferably illuminated using backlighting to enhance readability even in dim light situations. In a different location, light-emitting diodes 150 of various colors provide visual feedback information to a user regarding features such as battery power, radio signal strength, or menu function currently in use.

FIG. 2 shows a cross sectional view of the numeric keypad 100 taken along line 2—2 shown in FIG. 1. The keys 110 protrude from the front housing 180 of the keypad 100. The height 215 of a non-home key is approximately 4.75 millimeters, which allows for quick registry of a keypress by the electronic device and accurate tactile sensing of the non-home key by a user's finger. Although the surface 115 of the non-home keys is shown as flat, it may alternatively be concave or another configuration to contrast with the surface of the home key. The maximum height 265 of the home key is approximately 3.75 millimeters, which is one millimeter or twenty-one percent shorter than the non-home keys. Because the surface 165 of the home key 160 in this example is concave, the height of the home key varies from approximately 2.75 millimeters at the nadir to approximately 3.75 millimeters at the edges. A finger can detect less than a one millimeter difference in key height, however, to make the height difference obvious to users, a minimum ten percentage height difference is recommended as long as that percentage difference involves a height difference of at least one millimeter.

Thus, the numeric keypad configuration facilitates location of a home key even in situations when a user does not

look at the keypad. Once a home key is located, the height of the home key provides tactile information to the user regarding the proximity of the surrounding non-home keys which have a different height. This encourages quick and accurate keypresses. While specific components and features of the numeric keypad configuration are described above, modified components or features could be employed by one skilled in the art within the true spirit and scope of the present invention. The invention should be limited only by the appended claims.

We claim:

1. A keypad having multiple keys arranged in a matrix having at least three rows and at least three columns, comprising:

a home key having a numeric label and a home key height;

a first additional key, adjacent to the home key, having a first non-home key height greater than the home key height;

a second additional key, adjacent to the home key, having the first non-home key height;

wherein the home key is between the first additional key and the second additional key;

wherein the home key, the first additional key, and the second additional key are arranged along a column of the matrix;

a third additional key, adjacent to the home key, having a second non-home key height greater than the home key height;

a fourth additional key, adjacent to the home key, having the second non-home key height;

wherein the home key is between the third additional key and the fourth additional key;

wherein the home key, the third additional key, and the fourth additional key are arranged along a row of the matrix.

2. A keypad according to claim 1 wherein a surface of the home key is concave.

3. A keypad according to claim 1 wherein a surface of the first additional key is planar.

4. A keypad according to claim 3 wherein a surface of the second additional key is planar.

5. A keypad according to claim 1 wherein a surface of the first additional key is convex.

6. A keypad according to claim 5 wherein a surface of the second additional key is convex.

7. A keypad according to claim 1 wherein the numeric label is "5."

8. A keypad according to claim 1 wherein the first non-home key height is equal to the second non-home key height.

9. A keypad having multiple keys arranged in a matrix having at least two rows and two columns, comprising:

a housing;

an outwardly-projecting home key, situated in the housing in a second row and a second column of the matrix, having a home key height;

an outwardly-projecting first non-home key, situated in the housing in the second row and a first column of the matrix adjacent to the home key, having a non-home key height different from the home key height;

an outwardly-projecting second non-home key, situated in the housing in a first row and the second column of the matrix adjacent to the home key, having the non-home key height; and

an alphanumeric label, situated on the housing adjacent to the home key.

10. A keypad according to claim 9 wherein the home key height is less than the non-home key height.

11. A keypad according to claim 9 wherein the alphanumeric label is illuminated.

12. A keypad according to claim 9 further comprising:

an outwardly-projecting second non-home key, situated in the housing adjacent to the home key, having the non-home key height,

wherein the home key, the first non-home key, and the second non-home key are arranged along a line.

13. A keypad according to claim 9 further comprising:

a light-emitting diode situated in the housing.

14. A keypad according to claim 9 wherein the alphanumeric label is "5."

15. A radiotelephone having a keypad with multiple keys arranged in a matrix having at least three rows and three columns, comprising:

a housing;

a home key, situated in the housing, having a home key height;

an alphanumeric label, situated on the housing adjacent to the home key;

a first additional key, situated in the housing adjacent to the home key, having a non-home key height that is greater than the home key height;

a second additional key, situated in the housing adjacent to the home key, having the non-home key height;

wherein the home key is between the first additional key and the second additional key;

wherein the home key, the first additional key, and the second additional key are arranged along a column of the matrix;

a third additional key, situated in the housing adjacent to the home key, having the non-home key height;

a fourth additional key, situated in the housing adjacent to the home key, having the non-home key height;

wherein the home key is between the third additional key and the fourth additional key; and

wherein the home key, the third additional key, and the fourth additional key are arranged along a row of the matrix.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 5,926,119  
DATED : August 9, 1999  
INVENTOR(S) : Lindeman

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Claim 12

In column 4, line 17, please replace "second" with --third--.

Claim 12

In column 4, line 21, please replace "second" with --third--.

Signed and Sealed this  
Fourth Day of January, 2000

*Attest:*



*Attesting Officer*

*Acting Commissioner of Patents and Trademarks*

**United States Patent** [19]  
**Gottlieb**

[11] Patent Number: **4,737,656**

[45] Date of Patent: **Apr. 12, 1988**

[54] **MULTIPLE SWITCH CONTROL SYSTEM**

[75] Inventor: **Morton S. Gottlieb, Rockville, Md.**

[73] Assignee: **Izumi Corporation Industries, Inc., Patchogue, N.Y.**

[21] Appl. No.: **847,272**

[22] Filed: **Apr. 2, 1986**

[51] Int. Cl.<sup>4</sup> ..... **H02J 1/00**

[52] U.S. Cl. .... **307/10 R; 307/102 S; 307/112; 340/52 R**

[58] Field of Search ..... **307/9, 10 R, 115; 74/552, 558, 484 R; 484 H, 473 SW; 364/424; 340/22, 572, 573, 51, 52 R, 52; 200/61.54, 61.55, 61.56, 61.57, 56 R, 61.35; D1/192, 175**

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*Assistant Examiner*—Paul Ip

*Attorney, Agent, or Firm*—Stephen E. Feldman

[57] **ABSTRACT**

A plurality of control switches are located in the hub of a steering wheel of a vehicle. The switches are connected to a remote control distribution terminal by a single connector. Actuation of each switch creates a switching voltage identifiable with that switch by a control circuit in the remote control distribution network. Reference voltages of predetermined values are applied selectively to individual control circuits in a circuit network. A control circuit in the network identifies the actuation of its associated switch by comparing the value of the switch created voltage with a predetermined voltage reference and the effect of the switch created voltage value on the adjacent control circuit.

**4 Claims, 3 Drawing Sheets**

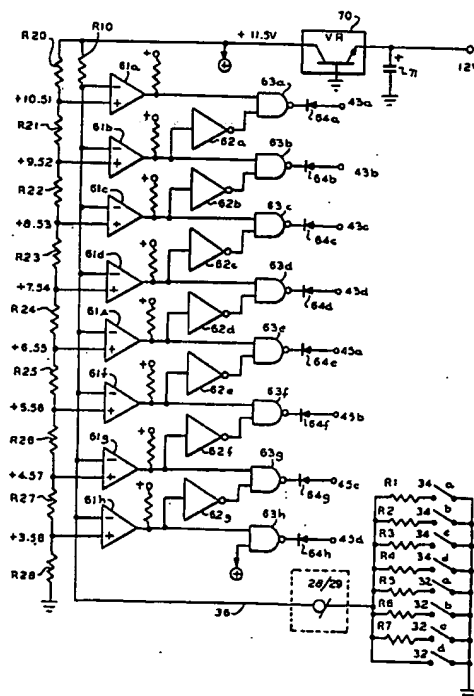


FIG. 1

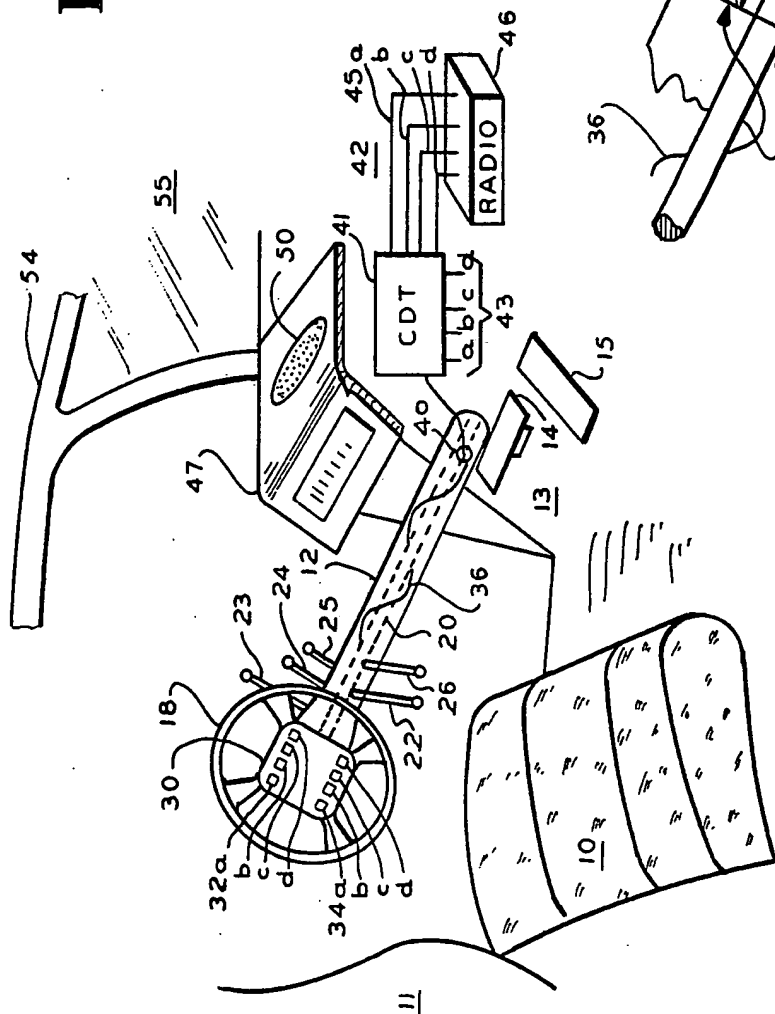
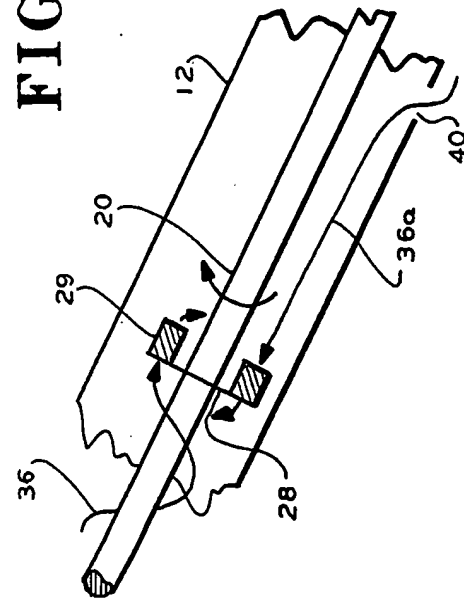


FIG. 1a



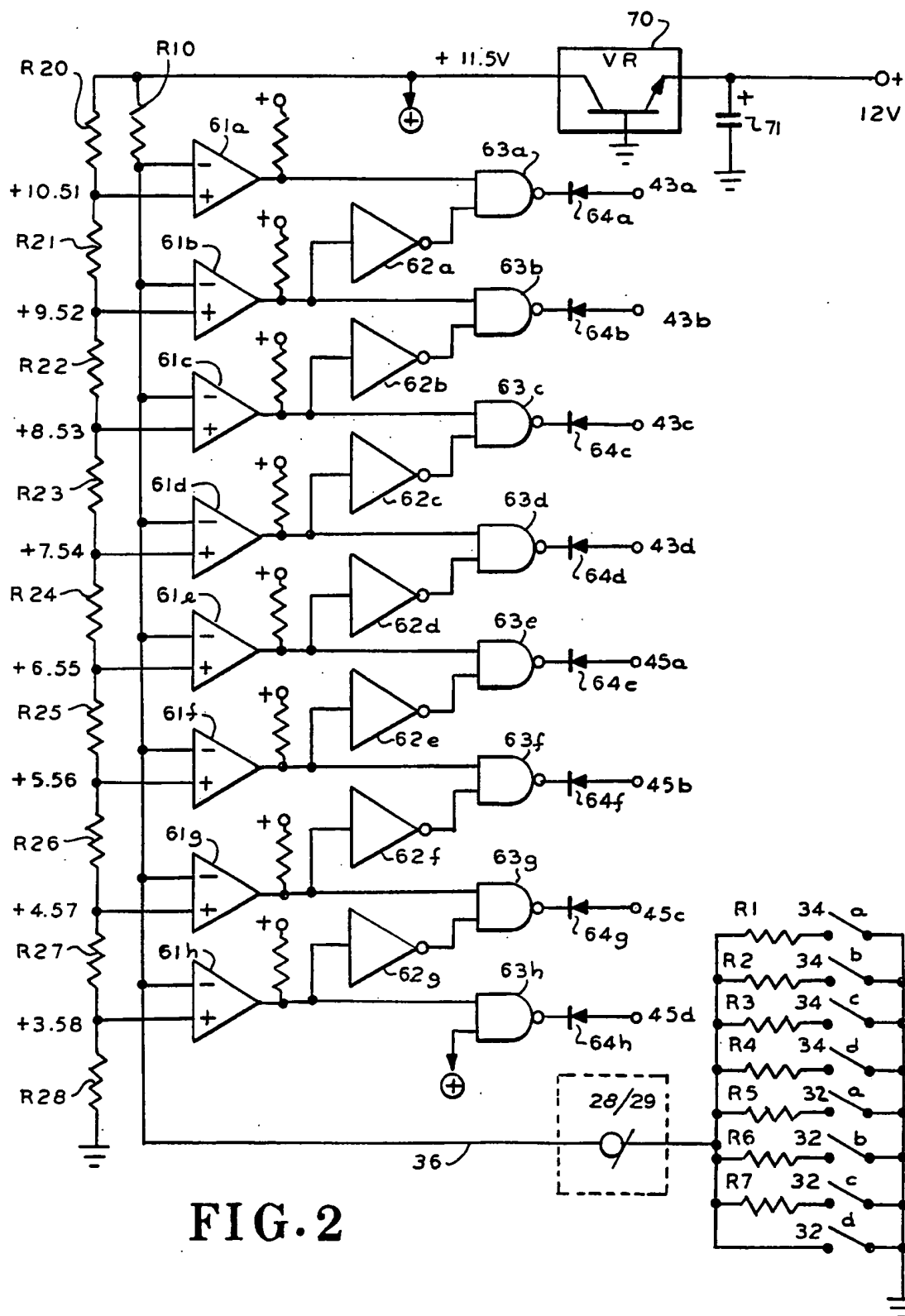


FIG. 2



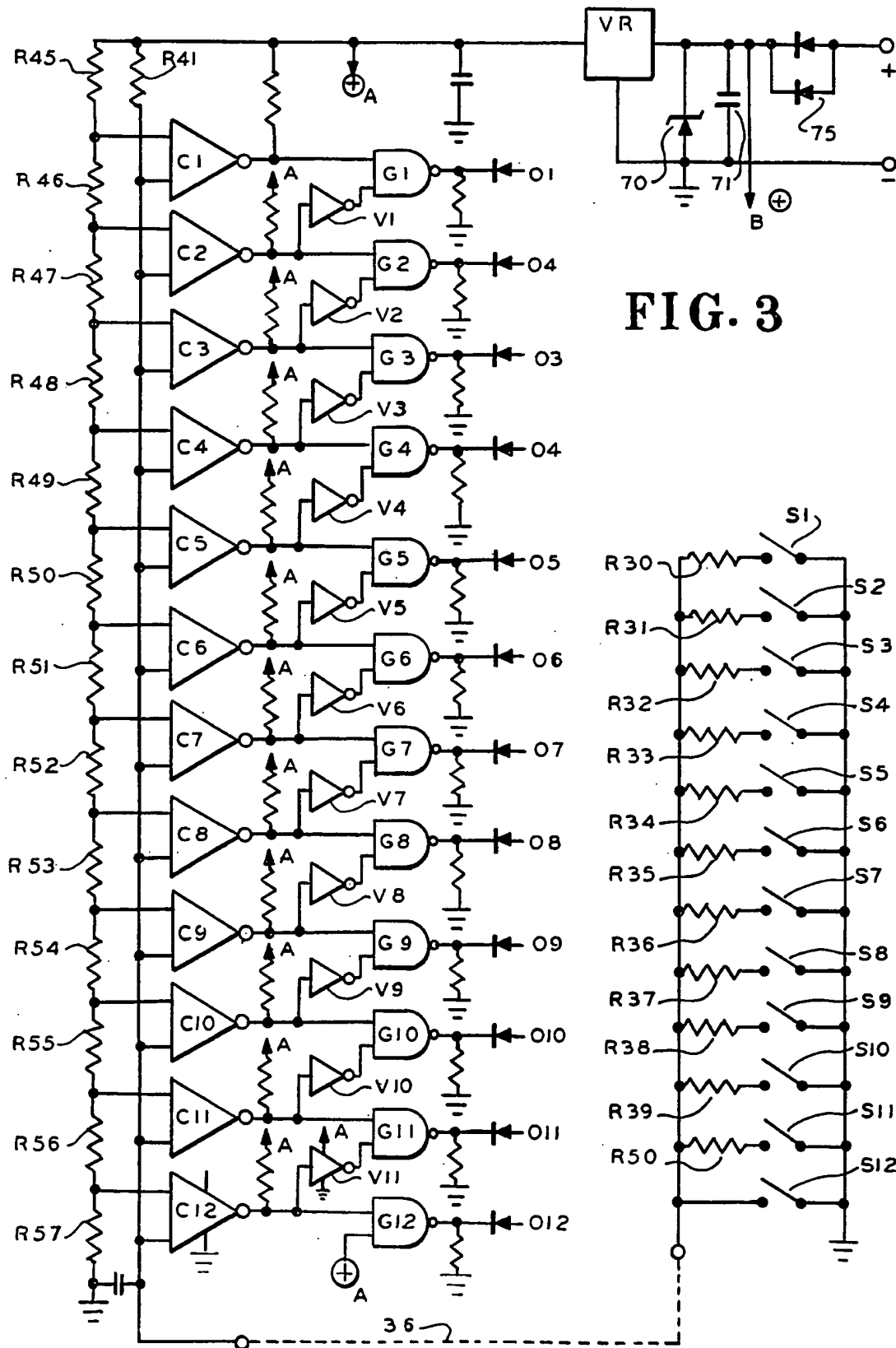


FIG. 3

## MULTIPLE SWITCH CONTROL SYSTEM

### BACKGROUND OF THE INVENTION

The present invention relates to remote control systems and in particular multiple switch control systems for control of accessory equipment and/or apparatus in a motor vehicle such as radio, telephone, cruise control, television and turn signals, for example in which the controls for the various accessories are centrally located, for driver convenience, but remote from the accessory.

In the past, motor vehicles, such as passenger automobiles and trucks were designed with the controls for various accessory equipment such as radio, head lights, and windshield wipers for example, located on the dash board or in a console close to the driver of the vehicle so that the controls of the accessory equipment were easily accessible to the driver. The location of these controls were not always driver convenient because what was convenient to one person was inconvenient to another person because of the wide range of the size of people driving motor vehicles. Also, often the concept of eye appeal took preference over driver convenience and accessibility where location of controls of accessory equipment was concerned.

When turn signals were added as motor vehicle accessory equipment the controls for these signals were generally located on the steering column, very close to and conveniently accessible to the driver, along with the shift control for the transmission of the vehicle.

Subsequently, other controls such as head light control, windshield wiper and washer controls, horn and cruise control were also located on the steering column, along with the steering wheel tilt control. The placement of these several controls on the steering column made these controls more readily accessible to the driver but this attempt at centralization of this plurality became confusing to the driver. In order to reduce the confusion these controls were combined, as much as deemed practical, and were separated or spread out around the steering column where ever practical. This took so much space on the steering column that placement of additional controls on the steering column is seen as not practical from a space stand point and only adding to driver confusion, from the multiplicity of controls standpoint.

Current thought for the design and placement of additional controls for other accessories of a motor vehicle or to remove some accessory controls from the steering column is to place additional controls for other accessories closer to the driver and in an area where the driver can view the controls more readily without removing his eyes from the road or with minimal eye removal from the road while the vehicle is in operation. The hub or central area of the steering wheel has been considered a desirable area in which to place additional controls. Placement of controls for accessory equipment in the hub area or central area of the steering wheel will place these controls closer to the driver and in a more convenient area of view for the driver than previously located but where controls located on the steering column are in a stationary location, controls located in the hub area or central area of the steering wheel would rotate with the steering wheel when the steering wheel is turned while steering the vehicle and the use of a wire harness containing a plurality of wires or control lines loosely positioned about the steering

wheel shaft to permit rotation of the steering wheel presents the danger of binding the steering shaft.

### SUMMARY OF THE INVENTION

The present invention overcomes the problem incurred in the use of a multiple wire, wire or control harness when locating a plurality of control switches in the hub area of a steering wheel by using single wire or single line control for a plurality of switches. The single line control system permits the use of a plurality of switches positioned in the steering wheel hub area, which rotates with the steering wheel when the vehicle is being steered by the driver. A single lead or control line connects the plurality of switches with a control distribution terminal remotely located from the steering wheel hub. The single control line is loosely gathered about the steering wheel shaft, so as to permit turning the steering wheel, and therefore the steering wheel shaft without the danger of binding the steering shaft by the control line. The single control line extends from the control switches in the hub of the steering wheel, down the steering shaft and to the control distribution terminal which maybe located on the fire wall or at some other remote location under or behind the dash board of the vehicle.

### OBJECTS OF THE INVENTION

It is an object of the invention to provide a multiple switch, multi-control control system for a motor vehicle in which a plurality of switches are located in the hub of the steering wheel of the vehicle and the control distribution terminal is located remote of the switches and a single line collectively connects the switches and the control distribution terminal with the single line connector between the switches and the distribution terminal loosely following part of the steering wheel steering shaft.

Another object is to provide a multiple switch, multi-control control system for controlling accessory equipment in a motor vehicle in which the driver actuatable switches are located in the hub of the steering wheel and the control distribution terminal is located remote from the driver actuatable switches with a single lead control line connecting the drivers actuatable switches and the control distribution terminal, the single lead control line extending along and loosely about the steering shaft of a motor vehicle.

### BRIEF DESCRIPTION OF THE DRAWINGS

The objects above and other objects will become apparent when reading the description of invention with reference to the drawings in which:

FIG. 1 is a pictorial representation of part of the interior of a motor vehicle representing one use of the present invention;

FIG. 1a is a representation of an alternate rotatable electric connection usable in practicing the invention;

FIG. 2 is a circuit diagram of an eight switch, single line logic switch control system; and

FIG. 3 is a circuit diagram of a twelve switch, single line logic switch control system.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 represents pictorially, that section of a motor vehicle occupied by the driver when operating the vehicle. The seat 10 and seat back 11 are represented in

part with the steering column 12 extending out of the floor section 13. A brake pedal 14 and an accelerator pedal 15 are represented spaced on the floor. At the top of the steering column 12 is a steering wheel 18. The steering wheel is connected to a steering shaft 20, (shown in broken line form) by a threaded shaft and nut combination, not illustrated. The steering column 12 is shown with a fixed cover over the steering shaft 20. The shaft rotates as the steering wheel 18 is turned but the steering column or cover remains stationary or fixed. There is, as indicated a space between the steering wheel shaft and the steering column or cover. In the area between the steering column or cover 12 and the steering shaft 18 some controls and control leads or cables are located. These controls are represented as the lever 22, for the transmission control, lever 23 for the turn signal control and head light control, lever 24 for the windshield wiper and washer control, lever 25 for the steering wheel tilt control and lever 26 for the horn control. As will be appreciated, these various levers for the various accessory controls take a great deal of space both around the steering column and, since the levers are connected to the accessory equipment with which it is associated take a reasonable amount of space in the area between the inside of the steering column 12 and the steering wheel shaft 20.

Although the drawing is merely representative of controls on a steering column, one can see that driver confusion could easily develop because of the multiplicity of levers or controls in the same area and especially since the control levers are under the steering wheel.

In the hub 30 of the steering wheel 18 there are represented two groups of four buttons. The group of buttons 32a, b, c, and d represent four switches that may, for example control the radio. The group of buttons 34a, b, c and d represent four switches that may control the cruise control for the engine. Each switch of the eight switches located in the hub 30 of the steering wheel 18 is connected to the single lead 36 which lead is loosely wound around the steering shaft 20 and exits out an opening 40 in the steering column 12. The lead 36 extends to the control distribution terminal CDT 41, secured to the fire wall 42. The circuit of the control distribution terminal is shown in more detail in FIG. 2. Control lines 45a, b, c and d are illustrated as extending from the terminal 41 to the radio 46. It will be seen that a dash board 47 (shown in part) covers the fire wall area where the terminal 41 and the radio 46 are secured. In the dash board 47 a radio speaker 50 is represented.

It will be obvious to one who drives a motor vehicle that the switches 32a, b, c and d and 34a, b, c and d are both accessible and convenient to the driver when the driver is behind the steering wheel and operating the vehicle. The windshield 55 and some frame structure 54 are also represented.

It should be understood that the specific placement of the switches or buttons 32a, b, c and d and 34a, b, c and d in the hub 30 of the wheel 18 is a matter of choice and design. The specific size and design of the hub 30 is also a matter of choice. Although eight switches or buttons are illustrated fewer than eight or more than eight may be used, if desired. The buttons or switches used may be any type of 12 volt electric switch appropriate for such use, such as snap switches or pressure sensitive switches, without limitation. The accessory equipment controlled by the set of switches may be radio, as illustrated or a cruise control, as represented by the control lines 43.

If desired, other buttons or switches may be added and selectively located in the hub 30 for controlling a television receiver located in the vehicle or buttons or switches used for dialing a telephone may be located on the hub of the steering wheel.

Certainly the buttons and/or switches are within easy view of the driver and the buttons, may be identified as to their function by a panel designed for such identification.

FIG. 1a shows an electrical connection which avoids a long loosely wound line around a rotating shaft by providing a conductive disc and at least one electrical brush riding on the conductive disc and one brush coupled to and riding with the disc as the disc rotates with the steering shaft. The disc part 28 is nonconductive and is coupled or fixed to the steering shaft 20 so that the disc 28/29 rotates with the shaft. The disc part 29 is conductive and is attached to disc part 28. The lead 36 extending from the switches or buttons 32 and 34 makes contact with the disc part 29, on its upper surface. The lead 36 may be fixed to the disc part 29 or ride on the disc part 29, as desired, however, electrical contact is made between the two conductors. The lead 36a is preferably a fixed position lead and makes riding or sliding contact on the lower surface of disc part 29. The lead 36a extends out of the steering column or cover 12 via opening 40.

The structure represented in FIG. 1a is an alternate structure that may be used in place of the single, continuous lead structure such as that represented in FIG. 1.

Referring to FIG. 2, a circuit diagram of the multiple switch single lead control system is represented in which the switches 32a, b, c and d and 34a, b, c and d are represented in the lower right corner of the drawing. The alternate structure for a moving or rotary connection as shown in FIG. 1a is represented and may be used in the system as represented by the broken line box around the call out 28/29. The lead 36 represents the correspondingly identified lead in FIG. 1.

In general, each switch (34a, b, c and d and 32a, b, c and d) has associated there with a resistance (R1 through R7) of progressively increasing resistance value. When any one switch is closed the voltage applied along lead 36 and therefore to each of the voltage sensitive logic circuits, is a function of the value of the input voltage (a regulated 11.50 volts) and the value of the resistance (R1 through R7) placed in the circuit below the resistance R10.

Each control circuit is associated with a particular switch by virtue of the voltage values to which the control circuit is sensitive. Each control circuit includes a comparator (61a through 61h) and a NAND gate (63a through 63h) Each comparator has applied there to a reference voltage, the value of which is individually selected for the position of the control circuit in the network.

When the value of the reference voltage exceeds the value of the switch applied voltages the output of the comparator component is logic 1. When the value of the reference voltage is less than the value of the switch line voltage the output of the comparator component is logic 0.

When a logic 0 and a logic 1 are applied to the NAND gate the output of the NAND gate is logic 1 which corresponds to "OFF" for the purpose of controlling any apparatus by the control circuit.

In the preferred embodiment a plus 12 volt supply is fed to a voltage regulator, VR which provides a regu-

lated output of +11.50 volts. This +11.50 volts is applied to the reference voltage line to ground and to the switching level line to the switches to ground. The reference voltage level line includes spaced resistors R20 through R27 of substantially equal resistance value so that the reference voltage applied to the control circuits in the network will be sequentially reduced in value. The resistance R28 is of a higher resistance value than the individual resistors R20 through R27 in order to hold the reference voltages at the desired respective levels.

With the resistors R20 through R27 at 1000 ohms (1k) value and resistor R28 at 3600 ohms (3.6k) value and an input voltage of +11.5 volts, the reference voltage at points between successive resistors R20 through R27 as applied to the control circuits of the network will be progressively reduced in value as the control circuits appear in the network. The values of the reference voltages as applied to the comparators of the control circuits in the network remains substantially stable.

The switching voltage level line receives the +11.50 voltage input through a resistor R10 and is thence coupled to the second input of each comparator, each comparator having a reference voltage input and a switching voltage input. Each comparator 61a through 61h is such that when the switching voltage applied to the switching input exceeds the reference voltage applied to the reference voltage input the output of the comparator is logic 0 (low). When the voltage levels are reversed, ie the reference voltage level exceeds the level of the switching voltage the output of the comparator is logic 1 (high).

The switches 32a, b, c and d and 34a, b, c and d correspond to the switches that are located in the hub 30 of the steering wheel 18 in FIG. 1. When one of these switches 32a, b, c or d or 34a, b, c or d is closed, the closed switch completes a circuit to ground which includes into the switching voltage circuit a resistance which has the effect of changing the voltage level of the switching voltage that is applied to each of the comparators in the network. The value of resistance of the switching resistors R1 through R7 are so selected that when a switch 32a, b, c or d or 34a, b, c or d is closed, the switching voltage applied to the switching voltage terminals of the comparators will have a value which is lower than at least one reference voltage value applied to the network of comparators.

The value of the input voltage and the resistance value of the resistor R10 are considered. The value of the resistor R1 is then selected so that when switch 34a is closed the value of the switching voltage applied to the comparators will be less than the value of the reference voltage applied to comparator 61a but more than the value of the reference voltages applied to the comparators 61b through 61h. The value of resistor R2 is selected so that when switch 34b is closed to put resistor R2 in the switching voltage circuit the value of the switching voltage applied to the comparators will be less than the value of the reference voltages applied to the comparators 61a and 61b, but more than the value of the reference voltages applied to comparators 61c through 61h.

Let it be assumed that switch 34c is closed and therefore resistor R3 is put in the switching voltage circuit. Preferably resistor R3 has a resistance value of 22000 ohms (22k). With resistor R3 in combination with resistor R10 (10k) in the switching voltage circuit the value of the voltage appearing at the switching voltage termi-

nals of the comparators will drop from +11.50 v to +7.90 v. Since the value of the switching voltage is less than the value of the reference voltages applied to comparators 61a, 61b and 61c these comparators change their output from logic 0 (low) to logic 1 (high). Since the value of the switching voltage is more than the value of the reference voltages applied to comparators 61d through 61h, these comparators remain at logic 0 (low) output.

The outputs of the comparators 61a, 61b and 61c (logic 1, high) are fed to respective NAND gates 63a, 63b and 63c respectively. The outputs of the comparators 61b and 61c (logic 1, high) are also applied to inverters 62a and 62b respectively. The inverters invert the logic 1 (high) to logic 0 (low) and feed the inverted signal to NAND gates 63a and 63b respectively. Since NAND gate 63a is fed a logic 1 from comparator 61a and a logic 0 from inverter 62a the output of NAND gate 63a is logic 1, or "OFF". NAND gate 63b is also at logic 1 because of the logic 1 input from comparator 61b and the logic 0 input from inverter 62b. However, the NAND gate 63c is fed a logic 1 input from comparator 61c and a logic 1 input from inverter 62c and NAND gate 63c goes to logic 0 or "ON" for the accessory controlled by output 43c. The diode 64c is for isolation purposes. The logic 1 output from the inverter 62c is from the logic 0 input received from the output of the comparator 61d.

It will be appreciated that each of the NAND gates 63a through 63g are fed inverted logic signals from inverters which receive logic signals from associated comparators. NAND gate 63h receives a constant logic 1 signal and goes from normal logic 0 to logic 1 when comparator 61h goes from logic 0 to logic 1.

The outputs 43a, b, c and d and 45a, b, c, and d may be applied to a solid state device such as a PNP transistor which may serve as a solid state switch and be turned on when a logic 0 (low) appears at the output terminal.

An example of reference voltage values and switching voltage values that may be used when practicing the invention are as follows:

| Control Comparator | Reference Voltage | Switching Voltage |
|--------------------|-------------------|-------------------|
| 61a                | +10.51            | +10.00            |
| 61b                | +9.52             | +8.95             |
| 61c                | +8.53             | +7.90             |
| 61d                | +7.54             | +6.95             |
| 61e                | +6.55             | +5.98             |
| 61f                | +5.56             | +5.00             |
| 61g                | +4.57             | +4.05             |
| 61h                | +3.58             | +3.10             |

It should be understood that the value of the reference voltages and the value of the switching voltages used will depend on the operating values and tolerances of the electrical components used.

FIG. 3 is a circuit drawing of a single line multiple switch multi-control system used successfully, in practicing the invention.

A bank of switches S1 through S12 were located on a steering wheel hub of a vehicle. These switches were connected on the moving side of the switch to ground. Associated with each respective switch is a respective resistance, R30 through R40, the individual values of which were selected so as to create the desired switching voltage for application to the comparators C1 through C11, when one of the switches was closed

placing its associated resistor in the switching voltage circuit line along with resistor R41. It will be noted that switch S12 has no associated resistor so that when switch S12 is closed the voltage value in the switching voltage line is pulled to ground.

The resistors R45 through R57 form the reference voltage points along the reference voltage line and the comparators C1 through C12 compare the voltage levels similar to that described with respect to FIG. 2. NAND gates G1 through G12 respond to the logic signal outputs of the comparator with which the gate is associated and, in the case of gates G1 through G11, to the outputs of the inverters V1 through V11. NAND gate G12 receives a signal from the high input +A. The outputs 01 through 012 are individually turned "ON" or "OFF" in the same manner as that described with reference to FIG. 2.

The block VR represents a voltage regulator which is protected by the zener diode 70 and capacitor 71. The diodes pair 75 ensure the supply is of direct current characteristic.

Thus there has been shown and described a multi-switch single line multi-control circuit where the switches may be remotely located and connected to the control circuitry by a single lead or connector. Although an eight switch system and a twelve switch system have each been illustrated and described the invention may be used with fewer switches or more switches, if desired. Although values of voltage levels and electrical components have been provided these values are exemplary of values and levels that may be used in practicing invention. Other changes in the system may be made as will be recognized by those skilled in the art without departing from the concept and principals of the invention.

What is claimed is:

1. A control system for controlling accessory equipment in a motor vehicle wherein control switches are located in the hub of the steering wheel of said motor vehicle remote from the control circuit network, said control system including:

- (a) a source of power and a return;
- (b) a first voltage divider including at least a first resistance and a common junction between said source of power and said return;
- (c) a second voltage divider including at least a plurality of resistors in series connection between said source of power and said return;
- (d) a plurality of substantially identical, parallel circuits connected sequentially between said source of power and said return, each circuit of said plurality of circuits including at least a first input, a second input, a comparator, a NAND gate and a load;
- (e) said first input of each said circuit connected to said common junction for applying a first voltage to said comparator of each said circuit;

(f) said second input of each said circuit connected to said second voltage divider for applying a second voltage to said comparator for each circuit such that the value of said second voltage applied to the respective comparator is different from that voltage value applied to adjacent comparators as a function of the position of the circuit, of which the comparator is a part, along said second voltage divider;

(g) each said circuit of said plurality of circuits, except the first circuit of said plurality of circuits positioned along said second voltage divider further including one inverter said inverter connected between the output of said comparator and one of the inputs of said NAND gate of the parallel circuit in the higher adjacent position along said second voltage divider;

(h) a plurality of resistance means equal in number to the number of circuits in said plurality of circuits and connected in parallel connection to each other and each said resistance of said plurality of resistance means connected in series connection between said common junction and said return for changing the value of said first voltage when one or the other of said plurality of resistance means is electrically inserted between said common junction and said return; and,

(i) a plurality of switch means equal in number of said resistors in said plurality of resistance means and connected in parallel connection with each other and each switch connected in series connection with at least one of said resistances of said plurality of resistance means and each said switch connected to said return for electrically inserting a different resistance each into said first voltage divider circuit.

2. A control system as in claim 1 and in which said NAND gate of each said circuit, except the last circuit of said plurality of circuits, includes a first input connected to the output of the comparator of the circuit of which said comparator and said NAND gate are a part and a second input connected to the output of the inverter of the circuit next in sequence of appearance in said plurality of circuits.

3. A control system as in claim 1 and in which each switch of said plurality of switch means is a normally open switch.

4. A control system as in claim 3 and in which each said switch of said plurality of switch means is associated with a resistance element having a progressively different value of resistance, relative to the position of said switch in said plurality of switch means, for applying to each said first input of said comparator a voltage which differs in value according to which said normally open switch is closed.

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